Indian Journal of Agronomy **67** (2): 197–200 (June 2022)

Research Communication

Nitrogen-management options for different crop-establishment methods in wheat under rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system

SUDARSHAN S.[1], KAPILA SHEKHAWAT[2], S.S. RATHORE[3], RAJIV K. SINGH[4] AND VIPIN KUMAR[5]

ICAR-Indian Agriculture Research Institute, New Delhi 110 012

Received: February 2022; Revised accepted: June 2022

ABSTRACT

The present investigation was carried out at the research farm of the Indian Agriculture Research Institute, New Delhi, during winter (*rabi*) season of 2020–21 where 4 nitrogen (N)-management practices were evaluated under 4 establishment methods in 3 times replicated split-plot design. The results exhibited that, the zero tillage+residue (ZT + R) application recorded significantly better growth parameters, yield attributes, grain yield (4.99 t/ha), straw yield (8.03 t/ha) and economic returns (net B : C ratio of 2.01) of wheat over the other treatments. Among the N-management options, LCC-guided N application resulted in significantly higher grain (5.39 t/ha) and straw yield (8.36 t/ha) and economic returns (net B : C ratio, 2.20) over the remaining treatments. Therefore, LCC-guided N application under ZT + R in wheat proved a better option for better growth, productivity and higher returns in wheat under RWS.

Key words: Economics, LCC, Nitrogen management, No-till farming, Residue retention

Wheat (*Triticum aestivum* L.) is the second most important cereal crop in India, covering ~29.6 million ha, with the production of 99.7 million tonnes/year, (MoAFW, New Delhi, 2018). To meet the rising food demand, the productivity of rice–wheat cropping system must be enhanced on a sustainable manner. However, due to less turn-around period for wheat sowing, it is often delayed in rice–wheat systems. Hence, conservation agriculture (CA)-based rice–wheat system is gaining popularity among the farmers, especially in the farmers of North-western plains of Indo-gangentic plain. An increased productivity and resource conservation can be achieved through developing new crop-establishment methods and standardization N of management practices (Rathore *et al.,* 2022). Wheat has high N requirement, and its supply during the critical demand stages determines yield potential. The imbalance nutrient usages has been reported through a wider N : P : K ratio of 8.3 : 2.7 : 1 (Panwar *et al.,* 2019). Therefore an efficient and effective method of nutrient application is needed for intensive cereal system. Other benefits of ZT includes uniform mineralization and less leaching losses during the growing season (Yadav *et al.,* 2020). In wheat, ZT has been widely adopted in the western IGP owing to the clear benefits it provides in terms of efficiency, profitability, environmental sustainability, and heat stress (Keil *et al*., 2015). N-management in no-till farming systems is an emerging issue. The precise timing of N application to wheat at various stages of its growth and development has a significant impact on yield and grain quality. In this regards, real-time corrective N-management is based on the periodic assessment of plant N status is a potential option for enhanced NUE (Bhat *et al*., 2015). To minimize N losses and increase crop N recovery, the timing of N application is critical. A leaf-colour chart (LCC) is a non-destructive and low-cost alternative to a chlorophyll metre that can quickly and accurately determines a crop's N status based on leaf colour (Bijay-Singh *et al*., 2002). Unlike rice, fertiliser applications in wheat must be synchronised with irrigation events, the fixed-time or adjustable-dose technique appears to be particularly promising (Singh, 2008). Despite all benefits of LCC-guided N management in wheat, its wide-scale adoption especially under ZT and other crop-establishment methods remains a challenge for farmers. Hence, nitrogen-management options for different crop-establishment methods in wheat under rice–wheat cropping system was planned to evaluate the impact of precision N management.

Based on a part of M.Sc. Thesis of the first author submitted to Indian Agricultural Research Institute, New Delhi in 2021 (unpublished)

[1]**Corresponding author's Email:** drrathorekapila@gmail.com
[1,5]M.Sc. Scholar, [2]Senior Scientist, [3,4]Principal Scientist, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi 110 012

The present investigation was carried out during the winter (*rabi*) season of 2020–21 at Research Farm, Division of Agronomy, Indian Agricultural Research Institute, New Delhi. The experimental site receives an average annual rainfall of 714 mm. Delhi has a semi-arid, sub-tropical climate with hot, dry summers and cold winters. The soil was medium in organic carbon (0.39%), low in available N (203.2 kg/ha), medium in available P (24.4 kg/ha) and high in available K (342.2 kg/ha). Wheat variety 'HD 2967' was grown. The field experiment was laid out in a split-plot design, with 4 establishment methods in the main plots, viz. CT, conventional wheat (CT-wheat), zero tillage (ZT)-wheat without residue (R), zero tillage (ZT)-wheat + rice residue @ 3 t/ha and Stale seed bed-CT and 4 nitrogen-management options, viz. control, recommended N application, modified N scheduling and LCC-guided N application with adjustable time N application using LCC matching with irrigation schedulein the subplots, for a total of 16 treatment combinations with 3 replications.

The results revealed that the plant height of wheat was not significantly influenced by crop-establishment methods. Dry-matter accumulation, crop-growth rate (CGR) increased substantially from 60 to 90 DAS, being significantly higher in ZT + R which remained statistically at par with ZT. Singh *et al.,* (2014) found that, the ZT planting method had a significant influence on growth parameters of wheat, when compared to the CT planting method. Dry-matter accumulation was the highest under LCC-guided N application (Table 1); however, it remained statistically at par with Mod. N scheduling. Whereas, the maximum crop-growth rate (CGR) was recorded with LCC-guided N application, which remained statistically at par with Mod. N scheduling and recommended dose nitrogen (RDN) and significantly higher than CT. Tillers increased substantially at 90 days after sowing (DAS) were significantly higher in LCC-guided N application which remained statistically at par with Mod. N scheduling and RDN. At 90 DAS, the maximum leaf area index (LAI) was recorded with ZT + R compared to other treatments. At 90 DAS, the LAI remained significantly highest with ZT + R and remained significantly at par with Mod. N scheduling and higher over the other treatments (Table 1). The use of some tools for in-season N management, such as LCC or chlorophyll metre or a Green Seeker sensor, or site-specific nutrient management (SSNM), and soil-test crop response (STCR) aids in meeting crop-nutrient requirements while increasing the crop growth rates in wheat (Jat *et al.,* 2014).

The spike length of wheat varied significantly ($P \leq 0.05$) under different crop- establishment methods (Table 2). The maximum grains/spike and effective bearing tillers (EBT) were recorded under ZT + R. The maximum grains/spike, maximum EBT, the highest grain weight/spike and the maximum 1,000-seed weight were recorded under LCC-guided N application which remained significantly higher over Mod. N scheduling, RDN and No-N. The highest grain weight/spike was recorded under ZT + R which remained significantly higher over ZT, SSB-CT and CT (Table 2). Maximum 1,000-seed weight were recorded under ZT + R which remained statistically at par with ZT, SSB-CT and CT. The grain yield of wheat was significantly influenced by different crop-establishment methods, the highest being under ZT + R method of establishment which remained statistically at par with ZT method of establishment but was found significantly higher than SSB-CT and

Table 1. Effect of crop-establishment methods and nitrogen management on growth parameters of wheat

Treatment	Plant height (cm)	Dry-matter accumulation (g/plant)	Tillers/plant (90 DAS)	CGR (60–90 DAS)	LAI (90 DAS)
Crop-establishment methods					
CT	92.6	614.9	277.5	10.55	4.32
SSB-CT	94.6	625.2	281.3	10.80	4.48
ZT	97.3	656.3	298.1	11.54	4.64
ZT + R	98.1	680.2	301.3	11.75	4.94
SEm±	1.02	9.05	3.51	0.03	0.01
CD (P=0.05)	3.60	31.94	12.39	0.08	0.02
Nitrogen-management options					
No-N	87.2	602.1	261.8	11.10	4.44
RDN	97.3	643.4	295.2	11.15	4.58
Mod. N	98.2	658.3	298.1	11.17	4.67
LCC	99.8	672.8	303.2	11.23	4.69
SEm±	0.92	7.97	9.43	0.03	0.01
CD (P=0.05)	2.69	23.40	27.68	0.08	0.02

CGR, crop growth rate; LAI, leaf area index; CT, conventional tillage; SSB, stale seed bed; ZT, zero tillage; R, crop residue; N, nitrogen; RDN, recommended dose of N; Mod. N, modified N scheduling; LCC, leaf-colour chart-guided N application; DAS, days after sowing

Tables 2. Effect of crop-establishment methods and nitrogen management on yield attributes, seed yields (t/ha) and economics of wheat

Treatment	EBT/m²	Grains/ spike	Grain weight/ spike	1,000-seed weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvesting index (%)	Net returns (× 10³₹/ha)	Net benefit : cost
Crop-establishment methods									
CT	260.8	44.5	1.71	38.4	4.37	7.26	37.5	66.68	1.61
SSB-CT	277.9	46.9	1.92	39.1	4.50	7.36	37.9	68.91	1.62
ZT	316.7	48.8	2.01	39.3	4.73	7.70	38.1	71.10	1.94
ZT+R	348.3	52.8	2.12	39.4	4.99	8.03	38.4	82.07	2.01
SEm±	12.65	1.13	0.03	0.24	0.11	0.12	0.69	2.13	0.05
CD (P=0.05)	44.63	4.00	0.11	NS	0.38	0.41	NS	7.50	0.18
Nitrogen-management options									
No-N	211.7	41.7	1.51	36.3	3.27	5.64	36.7	42.72	1.11
RDN	307.5	47.2	1.82	37.6	4.67	8.00	37.0	74.48	1.78
Mod N	332.1	50.8	2.14	40.5	5.26	8.34	38.8	87.18	2.09
LCC	352.5	53.3	2.20	41.8	5.39	8.36	39.2	90.38	2.20
SEm±	17.76	0.94	0.03	0.20	0.12	0.26	0.71	2.80	0.07
CD (P=0.05)	52.13	2.76	0.09	0.57	0.35	0.76	2.09	8.23	0.20

EBT, Effective bearing tillers; CT, conventional tillage; SSB, stale seed bed; ZT, zero tillage; R, crop residue; N, nitrogen; RDN, recommended dose of N; Mod. N, modified N scheduling; LCC, leaf-colour chart-guided N application

CT (Table 2, Fig. 1). The ZT + R treatment showed has 14.2% higher grain yield than CT, 10.9% higher than SSB-CT and 5.5% higher than ZT. The highest grain yield was also recorded under LCC-guided N application which was significantly higher than RDN, No-N but remained statistically at par with Mod. N scheduling (Table 2, Fig 1). LCC-guided N application resulted in 19.8% higher grain yield than No-N, 15.4% higher than RDN and 2.4% higher than Mod N scheduling. This could be attributed to the benefits of keeping residues, which include reduced water loss owing to the suppression of soil water evaporation, reduced runoff, increased soil organic carbon, and enhanced soil structure. Crop-residue management can help improve nutrient cycling and increase crop yields. Balanced nutrition management using decision-support tools like Nutrient Expert® improved wheat productivity over existing recommended practises (Mitra *et al*., 2019). Under ZT, the net returns were the highest compared with conventional methods and other tillage option. The N-mangement options clearly influenced the net returns and the maximum net returns were noted under LCC-guided N application and the minimum under No-N. Although the higher net

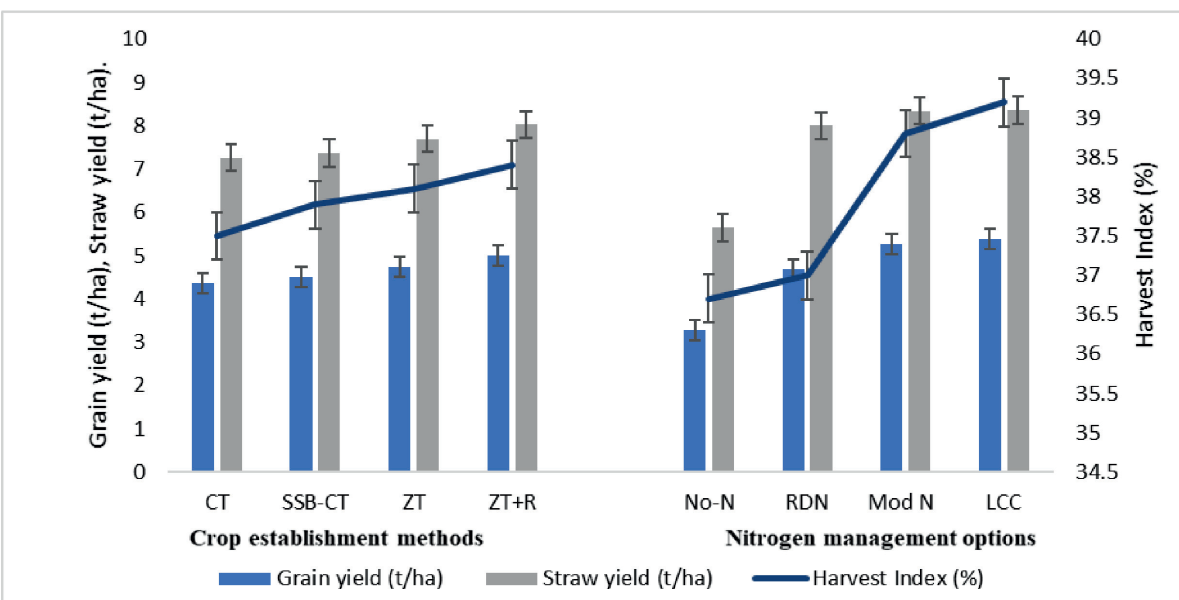

Fig. 1. Effect of crop-establishment methods and nitrogen management on yield of wheat

returns were observed under LCC compared with RDN and No-N, but it was statistically at par with Mod. N scheduling. Because of higher yield with lower cost of cultivation, the net returns in ZT + R establishment method and LCC-guided N application were higher. Srivastava *et al.,* (2009) also reported increased grain yield and benefit: cost ratio using SPAD and LCC-guided N application.

It can be concluded that, alternative crop-establishment methods and sensor-guided N application following the principles of conservation agriculture can help improve growth, productivity and economics of wheat. Nitrogen application under residue-retained field conditions often remains troublesome due to losses of N through volatilization and immobilization as applied nitrogen is retained on the surface of the residue, however a long-term study would be needed to further validate the results.

REFERENCES

Bhat, T.A., Kotru, R., Singh, K.N., Dar, S.B. and Ram, H. 2015. Real-time nitrogen management using leaf colour chart in rice (*Oryza sativa*) genotypes. *Indian Journal of Agronomy* **60**(1): 70–75.

Bijay-Singh, Yadvinder-Singh, Ladha, J.K., Bronson, K.F., Balasubramanian, V., Singh, J. and Khind, C.S. 2002. Chlorophyll meter and leaf colour chart-based nitrogen management for rice and wheat in north-western India. *Agronomy Journal* **94:** 821–829.

Jat, R.K., Sapkota, T.B., Singh, R.G., Jat, M.L., Kumar, M. and Gupta, R. K. 2014. Seven years of conservation agriculture in a rice–wheat rotation of Eastern Gangetic Plains of South Asia: Yield trends and economic profitability. *Field Crops Research* **164**: 199–210.

Keil, A., D'Souza, A. and Donald, A. 2015. Zero-tillage as a pathway for sustainable wheat intensification in the Eastern Indo-Gangetic Plains: Does it work in farmers' fields? *Food Science* **7**: 983–1,001.

MoAFW, New Delhi. 2018. *Agricultural Statistics at a Glance*, Ministry of Agriculture and Farmers' Welfare, Government of India, New Delhi.

Mitra, B., Kaushik, M., Sudarshan, K.D., Mondal, T., Das S., Banerjee, H., Ray, K. and Satyanarayana, T. 2019. Nutrient management in wheat (*Triticum aestivum*) production system under conventional and zero tillage in eastern sub-Himalayan plains of India. *Indian Journal of Agricultural Sciences* **89**(5): 775–784.

Panwar, A.S., Shamim, M., Babu, S., Ravishankar, N., Prusty, A.K., Alam, N.M., Singh, D.K., Bindhu, J.S., Kaur, J., Dashora, L.N., Pasha, L.M.D., Chaterjee, S., Sanjay, M.T. and Desai, L.J. 2019. Enhancement in productivity, nutrients use efficiency and economics of rice–wheat cropping systems in India through Farmer's participatory approach. Sustainability **11**: 122. DOI:10.3390/su11010122 *www.mdpi.com/journal/sustainability.*

Rathore, S.S., Babu, S., Shekhawat, Kapila, Singh, R., Yadav, S.K., Singh, V.K., Singh, Chandu. 2022. Designing energy cum carbon-efficient environmentally clean production system for achieving green economy in agriculture. *Sustainable Energy Technologies and Assessments* (52), Part B. *https://doi.org/10.1016/j.seta.2022.102190.*

Singh, B. 2008. Crop demand-driven site-specific nitrogen applications in rice (*Oryza sativa*) and wheat (*Triticum aestivum*): some recent advances. *Indian Journal of Agronomy* **53**(3): 157–166.

Singh, V.P., Singh, B., Thind, H.S., Singh, Y., Gupta, R.K., Singh, S., Singh, M., Kaur, S., Singh, M., Brar, J.S., Singh, A., Singh, J., Kumar, A., Singh, S., Kaur, A. and Balasubramaniam, V. 2014. Evaluation of leaf colour chart for need based nitrogen management in rice, maize and wheat in north western India. *Journal of Research*, *Punjab Agricultural University*, Ludhiana **51**: 239–245.

Srivastava, A.K., Singh, S., Diware, V.S. and Singh, H. 2009. Site-specific nutrient management in 'Mosambi' sweet orange. *Better Crops-India* **10**: 12–18.

Yadav, G.S., Babu, S., Das, A., Mohapatra, K.P., Singh, R., Avasthe, R.K. and Roy, S. 2020. No till and mulching enhance energy use efficiency and reduce carbon footprint of a direct-seeded upland rice production system. *Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro. 122700.*